ISSN No:-2456-2165

Review on the Growth of Sal Forest in Jharkhand

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Abstract:- This paper presents a review on the growth of the Sal forest. It is a natural forest having a large socio-economic value. Natural Sal forests occur mainly on sandy loam soil developed from under hilly areas in different parts of India. It is mainly found in Jharkhand, Bihar, Uttar Pradesh, West Bengal, Uttarakhand, and Himachal Pradesh. The variation in the growth, quality, and distribution of Sal is mostly influenced by soil-site characteristics. The growth of Sal forest is highly affected by physical properties (climate, temperature, and soil texture) and chemical properties like soil nutrients (Nitrogen, Phosphorus, and Potassium). The paper describes the physical and chemical properties which support the growth of the Sal forest and the knowledge of these physicochemical properties will help to design and manage the growth of Sal forest.

Keywords:- *Natural Sal forest, sandy-loam soil, soil properties, soil nutrients.*

I. INTRODUCTION

Sal is the most common and important tree species found in Jharkhand state. It is also known as *Shorearobusta* or sakhua or shala tree. This forest is spread across 10 million hectares (m ha) in India [1]. Sal is a species of tree belonging to the Dipterocarpaceae family [2] and is one of the best trees among all of the tree species. The tree is used for many purposes in our daily life. Its wood is used for construction works, furniture purposes, fuel wood, timbers, tennis, pillars, railway tracks, and seats [3-12]. Its resin is used as an astringent in Ayurveda medicine [13]. This tree is a crucial plant for many veterinary medicines including medicine for respiratory diseases. Sal is famous for its seed and oil and is also burnt as incense in Hindu ceremonies. The Sal fruit pulp is edible and contains sugar, gum, tartaric acids, malic acids, and citric acid having an important role in the food and cosmetic sectors. The extracted oil from Sal tree is greenish-brown in colour with a characteristic odour. The refined oil of Sal seed is used in chocolate manufacturing industries. It is also used for the production of vanaspati, pigments, lubricants, paints, biogas, and biodiesel. Besides, the de-oiled cake also has a good export market for cattle, poultry, and fish feed [14]. Sal seeds and its fruits are an important source of lamp oil and vegetable fat [15-16]. The wood from the Sal tree is resinous and durable and therefore it is especially suitable for constructing frames for doors and windows. The dry leaves of Sal are a major source for the production of leaf plates called patravali and leaf bowls in northern and eastern India [12, 17]. The leaves are also used fresh to serve readymade paan (beetle nut preparations) and small snacks such as boiled black grams, golgappa etc. The used leaves plates are readily eaten by goats and cattle that roam the streets freely, feed [18-19], resin or latex from heartwood [20] and tannin and gum from the bark [21-22]. The people of scheduled tribes and Scheduled caste use the total sources obtained through the Sal tree by using their whole product like seeds roots, stem, branches, and leaves.

Sal forest generally requires moist, slightly acidic sandy to clayey soil for appropriate growth. The natural regeneration of the Sal forest takes place by seeds. It has also been observed that it is also affected by anthropogenic disturbances in the environment. The regeneration gets poor via seeds under a higher degree of human interference and other daily activities such as burning, grazing and forest-cutting [23-24]. The Jharkhand state has a large area of Sal forest and these forests are originally spread out over thousands of square miles, especially in the districts of Hazaribag, Singhbhum, Palamu, and Ranchi [25]. Recently the work on the physicochemical studies of soil on the growth of the Sal forest has been an interest to many authors [26-36].

II. OVERVIEW OF THE STUDY OF SAL FOREST

A. Location of plant:

In 1998 Oudhia et al.[37] described that the Sal tree is natively found in the Indian sub-continent including south of the Himalayas, from Myanmar in the east to Nepal, and Bangladesh. In India, it extends from Assam, West Bengal, Orissa, and Jharkhand, west to the Shivalik hills in Haryana, and to the east of the Yamuna. The range of Sal forest extends through the Eastern Ghats and to the eastern Vindhya and Satpura ranges of central India. The Sal forest is distributed between 20–32°N latitude and 75–95°E longitude. The growth of the Sal forest is primarily maintained by climatic and edaphic factors [38].

B. Climate:

Sal forest located in Jharkhand state is facing various anthropogenic threats and is further aggravated by climate change impact. There is a very urgent need for the conservation of the Sal forest particularly rare, endangered, threatened, and endemic species of the Jharkhand State. Jharkhand has a large Sal forest area in Eastern India and is popularly known as the state of bushes. This area has a dense Sal forest and contains nearly the recorded forest area of 23,606 km^2 of the state which is 29.62% of the geographical area of the state. Out of these reserved forests constitute 18.59%, protected forests 81.29%, and Un-classed forests 0.15% of the total forest area. The floral wealth of the state is still unexplored. This is due to remoteness,

ISSN No:-2456-2165

inaccessibility, tough topography, and harsh climatic conditions. This requires the potential for new plant species. Indigenous communities are highly dependent on the Sal forest for sustenance and livelihood. The paper also describes the impact of climate changes on the proliferous growth of Sal-dominated forests found in Jharkhand. The temperature (27-33°C) humidity (10- 98.3%), and Rainfall (1000- 1500mm) are found most suitable conditions for the growth of Sal forest in Jharkhand Singh et al. [39] studied that the climates are characterized by three seasons: hot–dry summer (April–June), warm–wet rainy (middle June–September), and cool-dry winter (November–February), October and March are the transition months between seasons. The distribution, structure, and ecology of the forest influence the climate gradually [40-42]. The main consequence of changes in temperature, precipitation, and soil moisture content due to an increase in greenhouse gases, the majority of the forests will undergo shifts. Certain climatic regimes are associated with particular plant functional types [43-46], hence it is reasonable to assume that changes in climate would alter the distribution pattern and composition of forest ecosystems around the world.

The moisture behaves as the key player that would influence the distribution of Sal forest to shift towards northern and eastern India, with greater than 90% certainty. The studies emphasize the utility of the archived remote sensing data in providing location information in climate change studies.

C. Temperature:

The temperature of the soil is an important property because it influences the chemical, physical and biological processes associated with plant growth. Soil temperature fluctuates with the season, time of day, and local climatic conditions. The sun is the main source of heat for the chemical and biological activity of the soil [47]. A rise in the temperature of soil accelerates a chemical reaction, reduces the solubility of gases, and decreases the pH of soil [48]. It also plays an important role in the germination of seeds. The change in temperature will have an impact on the growth of biomass and the activity of the micro-organisms [49]. Soil temperature varies in response to exchange processes that take place primarily through the soil surface [48]. The Hazaribag district experiences great heat from March to May, when the maximum temperature reaches up to 44.4°C and during winter the same comes down to 2 - 3°C. The temperature obtained from the State Irrigation Department, show that the maximum day temperature varies from 20°C in January to 42°C in May, and the minimum night temperature from 10°C in January to 24°C in May. According to Bahuguna et al. [50] the temperature of Uttarakhand, India soil samples varied from 38 °C to 43 °C.

D. Rainfall:

The climatic condition around the Jharkhand state varies from Humid subtropical in the north to tropical wet, and dry in the south-east. The overall cumulative rainfall during the monsoon season (June-October) for the entire state of Jharkhand was found to be almost constant over many years [51]. The southwest monsoon starts in mid-June and ends in the month of October, bringing nearly all the state's annual rainfall, which ranges from about 1,000 mm (40 in) in the west-central part and more than 1,500 mm (60 in) in the south-west part of the state. About half of the annual rainfall occurs between the months of July and August. However, the trend analysis of cumulative rainfall during the monsoon season shows that rainfall has a fluctuating trend with a decrease of 26–270 mm in the north-western districts to an increase of 19–440 mm in the rest parts of the Jharkhand state. The spatial distribution of cumulative rainfall shows in Palamu, Garhwa, and many parts of the Ranchi, Ramgarh, Hazaribagh, Kodarma, Giridih, and Gumla show a declining trend of cumulative rainfall with a magnitude of 26–270 mm. Hazaribag district receives an annual rainfall of 1350 mm and more than 80 percent of rainfall occurs during the monsoon season. Rainfall data, obtained from the State Irrigation Department, show that about 85% of the annual rainfall is found in the rainy season, and 7–8 dry months occur during the annual cycle [52]. Long-term annual rainfall varies between 850 and 1350 mm. During the study period of two, annual cycles (May 2001 to June 2003), the annual rainfall was 1410 and 1125 mm respectively.

E. Soil type:

Gupta [53] studied and reported that the soil texture of the Sal forests areas was of sandy loam type, suitable for good Sal regeneration and high-quality trees. Shah [54] found that the sandy loam texture is a very common type of soil that support the growth of dense Sal forests along with some other valuable timber trees. Black [55] mentioned that the supply of water to plants usually is greater as the texture becomes finer. Soil texture also plays a very important role in the growth of plants that nutrient supply from the soil. The soil texture result is similar to the finding of Shrestha [56], verified by the work carried out in Royal Chitwan National Park (RCNP), Sidgel [57] in Sal forests in India. This may be due to the similar type of forest vegetation, i.e., Sal dominated forest. Chaudhary et al.[58] reported the comparative studies on two different forests of Sal trees with nutrient dynamics in Motichur and Chilla and Kumar et al.[59] also studied and reported the comparative studies on two different forests of Sal trees with nutrient dynamics depicting the characteristics of the soil under Sal forest in Ichak and Bishnugarh, District Hazaribag, Jharkhand forest have been incorporated in Table -1.

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	Ichak Sal forest			Bishnugarh Sal forest			Motichur Sal forest			Chilla Sal forest		
Soil Properties	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Temp (°C)	19.70	22.80	21.30	16.60	27.40	22.00	15.60	25.60	20.60	15.60	25.20	20.40
Humidity (%)	67.96	69.56	68.76	62.00	76.00	69.00	60.00	80.00	70.00	60.00	78.00	69.00
Moisture Content (%)	10.70	11.00	10.85	7.20	13.20	10.20	7.60	12.00	9.80	7.20	12.80	10.00
Water Holding Capacity (%)	68.00	70.00	69.00	55.90	77.70	66.80	60.00	80.00	70.00	56.00	76.00	66.00
pH	5.86	6.05	5.96	5.94	6.66	6.30	6.12	6.40	6.26	5.94	6.44	6.19
Organic Carbon (%)	1.56	2.32	1.94	1.32	2.40	1.86	1.53	2.99	2.26	1.29	2.20	1.75
Organic Matter (%)	2.65	3.47	3.06	3.05	4.05	3.55	2.66	3.95	3.31	2.24	3.83	3.04
Total Nitrogen (%)	0.17	0.34	0.26	0.22	0.31	0.27	0.24	0.32	0.28	0.20	0.32	0.26
Phosphate(mg/L)	0.54	0.92	0.73	0.59	0.89	0.74	0.68	0.90	0.79	0.72	0.91	0.82
Sodium(mg/L)	2.50	5.30	3.90	3.64	5.27	4.46	4.10	6.33	5.22	3.74	5.22	4.48
Potassium(mg/L)	8.70	10.50	9.60	10.20	15.14	12.67	8.24	10.50	9.37	10.00	15.04	12.52
Calcium(meq/100g)	6.30	7.40	6.85	6.55	7.12	6.84	6.26	7.86	7.06	6.54	7.00	6.77
Soil Fertility Index	20.57	21.57	21.07	17.20	19.27	18.24	19.15	20.92	20.04	17.11	19.22	18.17

Table1: Descriptive statistics of soil Physico-chemical properties under Motichur, Chilla, Ichak, and Bishnugarh Sal forest

F. Nutrient requirements

A unique balance of physical-chemical and biological components plays an important role to maintain soil quality and nutrient availability for the growth of Sal forest. In spite of the importance of macronutrients and micronutrients in plant growth and soil fertility is also an important parameter for the growth of Sal forest. Kaul et al. [60] estimated the nutritional uptake of a 35-year-old Sal stand from various parts of India. On the basis of their experimental work they observed that nutrient requirements for all site qualities decreased in the order of Ca>N> K>Na. The Ca requirement was found to be 1.5 times higher than that of N, 2 times that of K, and 5 and 7 times that of P and Na, respectively. The study shows that nutrient requirements are higher on better sites, and the rate of stem timber production is also greater. Kaul et al. in 1966 studied the effect of mineral (N, P, K, Ca, and Na) deficiencies in different Sal seedlings, and found that the deficiency of each of these nutrient elements causes prominent symptoms like premature defoliation, smaller leaves, thin taproot, and slow shoot growth. [61]. Deficiencies of N and P affect height growth to a greater extent while deficiencies of Ca influenced a shorter tap root and sparse lateral roots. The N- and K-deficient seedling leads to thinner and longer tap roots in Sal trees.

G. Nutrient content and cycling

Bhatnagar [62]analyzed the mineral contents (ash, CaO, MgO, N, K_2O, and P_2O_5) in Sal foliage from different site quality classes, which were classified on the basis of top height at the age of 80 years (first quality being the tallest). First-quality trees showed the lowest concentration (percent) of all minerals, whereas the lowest-quality trees showed the highest percentage of N, P, and K.

In a study of 21-year-old coppice of Sal forests, leaves contained the highest percentages of N, P, K, and Mg, while the bark had the maximum percentage of Ca for all categories of Sal trees, i.e. dominant, average, and suppressed [63]. The study calculated standing nutrient content in a Sal forest Table 2, and a comparison of leaf litter nutrients from different studies is presented in Table 3.

Plant part	N	P	K	Ca	Mg	Total
Leaves	59	6	18	40	7	130
Twigs	34	3	14	35	4	90
Branches	101	8	35	115	20	279
Bole	242	27	75	125	51	520
Bark	85	8	58	257	35	443
Total	521	52	200	572	117	1462

Table 2: Standing nutrient content of different parts of Sal tree (kg ha^{-1}) (Kaul *et al.*[51])

ISSN No:-2456-2165

N	P	K	Ca	Mg	Sources
59	2	23	57	18	Singh *et al.*[64]
72	4	23	83	13	Pande and Sharma[65]
46	9	19	77	10	Seth *et al.*[66]
59	6	18	40	7	Kaul *et al.*[51]

Table 3: Nutrients returned to the forest floor through leaf fall (kg ha^{-1})

The nutrient rates calculated in the four studies show little difference in the estimates of each nutrient. The climate of measurement years, age of the forest, and methods of measurements may have contributed to these differences and give information on different properties of the forest. One of the studies was in 21-year-old coppice forests, whereas the others were older than 35 years when they were measured. Similarly, the destructive method (trees were felled) was followed in the case of the study by Kaul et al.[63] while the others followed the litter-plot method (collected throughout the year at monthly or quarterly intervals from the plots laid out in the forests).

Litter (leaves and twigs) production in Sal forests ranged from 1010 to 6210 kg ha^{-1} $year^{-1}$ depending on the species composition and canopy cover [64-65]. Leaf litter decomposition is faster than twig decomposition [66]. Maximum decomposition was in the rainy season, and the turnover time to decompose the litter was 144 days [67]. After summer the rainfall usually starts in the last week of June, litter starts decomposing rapidly and by the time the next litter fall starts, most of it decomposed and incorporated into the soil [64]. Some Authors [68-69] found that the decomposition rate increased with increasing litter moisture and air temperature while decreased with increasing altitude and lignin content. The loss of litter for Sal was observed to be 56 percent of initial dry weight after one year. The major portion i.e. total decomposition of about 40–45 percent of litter was lost from May to August. This is due to higher temperatures and humidity [70] while loss reached over 85 percent by 365–669 days depending on the site and species under study [71]. Gangopadhyay et al. [72], found that during the transformation from green foliage to raw humus some of the elements viz.Ca, Mg, K, Na, and P were leached out while other elements like Si and Fe accumulated.

III. CONCLUSION

The Sal tree is not only a high source of hardwood timber for human beings but, is also important for the wild animals as well as different types of birds found in these areas. Due to the unique properties of Sal trees their roots, stems, branches, leaves, flowers, and fruits have been used for different purposes by the local people. This study on the growth of the Sal forest reveals that still this area has not been exploited. Thus research in this field will contribute to developing management systems through proper planning for conservation, and decision-making of nature. The study also gives important information on the various factors like climate, location, rainfall, temperature, humidity, organic matter, and soil N, P, K, and Ca which support the Sal forest found in these areas. These factors not only provide the strength of Sal forest but also provides the natural regeneration in huge amount. Soil Nutrient including Organic matter content, soil N, P, Na, K, and Ca plays an important role in the growth of Sal trees and their regeneration. There is an urgent need for the management of Sal forest for multiple products. In view of ecological and socio-economic reasons, multiple-product forest management will be a desirable and essential requirement for sustaining Sal forests in these regions. Policymakers toward managing Sal forest for multiple products can be achieved by implementing community-based forestry programs that require a commitment from local communities.

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